METHOD AND APPARATUS FOR A BLIND GAIN RATIO DETECTOR

Inventors: Allen He
              171 Wenatchee Common
              Fremont, CA 94539
              Nationality: China

              Andrew Prentice
              6249 Robin Court
              Pleasanton, CA 94588
              Nationality: Great Britain

              Hongzhi Zhao

Assignee: Koninklijke Philips Electronics N.V.
              Groenewoudseweg 1,
              5621 BA Eindhoven, NL

Carr & Storm, L.L.P.
670 Founders Square
900 Jackson Street
Dallas, Texas 75202

METHOD AND APPARATUS FOR A BLIND GAIN RATIO DETECTOR

TECHNICAL FIELD

5   The invention relates generally to communications systems and, more particularly, to a method and an apparatus for determining a blind gain ratio.

BACKGROUND

        Wireless communications systems generally involve the transmission of radio frequency (RF) waves from a base
10   antenna to a mobile station, such as a wireless telephone, wireless laptop, a wireless Personal Data Assistant (PDA), and the like. The radio frequency waves are modulated with information bits organized into frames and channels. Some of the channels carry signaling and control information to
15   help manage the communications, and other channels carry user data, such as voice, data, and the like.

        The channel information is generally digitized and modulated according to an amplitude and/or a phase-shift keying modulation technique, such as the Quadrature
20   Amplitude Modulator (QAM), Pulse Amplitude Modulation (PAM), Pulse Code Modulation (PCM), Differential Pulse-Code Modulation (DPCM), Phase-Shift Keying (PSK), Differential Phase-Shift Keying (DPSK), Offset Quadrature Phase-Shift Keying (OQPSK), Differential Quadrature Phase-Shift Keying
25   ($\pi/4$-QPSK), Gaussian Filtered Minimum Shift Keying (GMSK), and the like. These techniques generally use a constellation, which are known in the art, to equate a digital sequence, known as a symbol, to a pulse signal.

        The modulation techniques generally provide a mechanism
30   to restore the signal constellation in the event the signal becomes corrupted due to noise interference and signal fading. In particular, standards such as the 1Xtreme

Enhanced Version Data/Voice (1X-EV-DV) standard, based on the 1Xtreme standard for Code Division Multiple Access (CDMA) developed by Motorola, require the relative gain ratio of the Forward Shared Channel (FSHCH) to the Pilot

5 Channel (PCH) be transmitted in the Forward Shared Control Channel (FSHCCH). The relative gain ratio is then used to restore the signal constellation. All channels, including the FSHCCH, however, are susceptible to noise interference and signal fading, thereby possibly inhibiting the

10 restoration of the signal constellation in the event that the FSHCH containing the relative gain ratio becomes corrupted.

Therefore, there is a need for a method and an apparatus for determining the gain ratio of two channels

15 that are less susceptible to noise interference and signal fading. And, in particular, there is a need for a method and an apparatus for determining the gain ratio of the FSHCH to the PCH in standards such as the 1Xtreme CDMA standard.

SUMMARY

20 The present invention provides a method and an apparatus for determining the gain ratio of the gain of a first channel to the gain of a second channel. The gain ratio is determined by calculating the quotient of the average and/or sum of samples of the first channel divided

25 by the average and/or sum, respectively, of samples of the second channel.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, and the advantages thereof, reference is now made

30 to the following descriptions taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a schematic diagram of a network environment that embodies features of the present invention;

FIGURE 2 is a block diagram illustrating one embodiment of the present invention in which a gain ratio of the FSHCH gain to the PCH gain is determined;

FIGURE 3 is a data flow diagram illustrating one embodiment of the present invention in which a gain ratio is determined from a received FSHCH signal and a received PCH signal; and

FIGURE 4 is a block diagram illustrating one embodiment of the present invention in which a gain ratio of the FSHCH gain to the PCH gain is determined from the sum of the received FSHCH samples and the sum of the received PCH samples.

DETAILED DESCRIPTION

In the following discussion, numerous specific details are set forth to provide a thorough understanding of the present invention. However, it will be obvious to those skilled in the art that the present invention may be practiced without such specific details. In other instances, well-known elements have been illustrated in schematic or block diagram form in order not to obscure the present invention in unnecessary detail. Additionally, for the most part, details concerning telecommunications and the like have been omitted inasmuch as such details are not considered necessary to obtain a complete understanding of the present invention, and are considered to be within the skills of persons of ordinary skill in the relevant art.

It is further noted that, unless indicated otherwise, all functions described herein may be performed in either hardware or software, or some combination thereof. In a preferred embodiment, however, the functions are implemented

in hardware in order to provide the most efficient implementation. Alternatively, the functions may be performed by a processor such as a computer or an electronic data processor in accordance with code such as computer

5   program code, software, and/or integrated circuits that are coded to perform such functions, unless indicated otherwise.

The principles of the present invention and their advantages are best understood by referring to the illustrated embodiment depicted in FIGURES 1-4.

10   Referring to FIGURE 1 of the drawings, the reference numeral 100 generally designates a portion of a communications network which embodies features of the present invention. Specifically, the communications portion 100 comprises a base transceiver station (BTS) 110

15   configured for communicating to a mobile station (MS) 112, such as a wireless telephone, wireless computer, Personal Data Assistant (PDA), or the like, via an RF interface 114 conforming to one or more wireless communications standards, such as Code Division Multiple Access (CDMA), Time Division

20   Multiple Access (TDMA), Global Systems Mobile (GSM), and the like. This disclosure discusses the invention in terms of CDMA technology, specifically, the 1Xtreme standard, but may be utilized with any technology, wireless or wireline, in which the relative gain of multiple channels is to be

25   determined, and in which the assumptions stated herein are applicable.

Accordingly, the RF interface 114 comprises a reverse-link (*i.e.*, MS-to-BTS communications) (not shown) and a forward-link 116 (*i.e.*, BTS-to-MS communications), each link

30   configured into one or more frames (not shown). Each frame of the forward link 116 comprises, among others, one or more Forward Shared Channel (FSHCH) samples 118 and Pilot Channel

(PCH) samples 120. The FSHCH samples 118 generally provide user data, such as voice, data, and the like, and the PCH samples 120 generally provide a synchronization signal for synchronizing the BTS 110 and the MS 112. The channels and

5   the framing of the channels are well known in the art and will not be discussed in greater detail except insofar as is necessary to disclose the present invention.

FIGURE 2 illustrates one embodiment of the present invention in which the relative gain ratio of the gain of

10   the FSHCH samples 118 to the gain of the PCH samples 120 is determined. The BTS 110, or some other component such as a Base Station Controller (BSC), a Mobile Switching Center (MSC), or the like, converts the values of the FSHCH samples 118 into energy values for the shared channel ($E_s(i)$) 210,

15   where the "i" represents the ith sample. The BTS 110 then applies an FSHCH gain factor (A_d) 212 to the $E_s(i)$ 210, as indicated by a multiplication function 214, producing a transmitted FSHCH signal 215 equivalent to ($A_d * E_s(i)$). The A_d is generally constant for all FSHCH samples 118

20   within a frame of data. The process of converting the FSHCH samples 118 to $E_s(i)$ 210, and applying the A_d 212 are considered well known in the art and, therefore, will not be discussed in greater detail, except insofar as is necessary to describe the present invention.

25   Similarly, the BTS 110 converts the PCH samples 120 to energy values $E_p(i)$ 216, to which a PCH gain factor (A_p) 218 is applied by a multiplication function 220. The result ($A_p * E_p(i)$) is the transmitted PCH signal 221. The PCH gain factor A_p is generally constant over time, $i.e.$, constant

30   over multiple frames.

The transmitted FSHCH signal 215 and the transmitted PCH signal 221, $i.e.$, ($A_d * E_s(i)$) and ($A_p * E_p(i)$),

respectively, are organized into frames, creating the transmitted signal 222, which is transmitted via the RF interface 114.   The process of organizing the data into frames and transmitting the data via the RF interface 114 is

5   well known in the art and, therefore, will not be discussed in greater detail.

The transmitted signal 222 is generally further affected by channel gain (A_c) 223, also known as channel attenuation, as indicated by a multiplication function 224.

10   Generally, the transmitted signal 222 is degraded by such things as path loss, multi-path fading, and the like. Therefore, the received FSHCH signal is represented by the product of the energy of the shared channel, the FSHCH gain, and the channel attenuation, i.e., $E_d(i) * A_d * A_c$, and the

15   received PCH signal is represented by the product of the energy of the shared channel, the PCH gain, and the channel attenuation, i.e., $E_p(i) * A_p * A_c$.   Upon receipt of the received signal 228, the MS 112 applies a gain rate calculator 226, which is described further below with

20   reference to FIGURE 3, the result of which is the approximation of the ratio of the FSHCH gain to the PCH gain, i.e., A_d / A_p.

FIGURE 3 is a data flow diagram of one embodiment that may be used to implement the gain ratio calculator 226

25   (FIG.2).   Specifically, the gain rate calculator 226 receives the received signal 228 and performs steps 310-316, resulting in the gain rate ratio 230 (FIG. 2).

Processing begins in step 310, wherein the received signal 228 is processed.   Generally, step 310 processes the

30   received signal 228 by separating the channels and symbols, and converting the channels into the energy of each received symbol.   The result of step 310 is the received FSHCH, which

is equivalent to the product of the transmitted FSHCH signal $E_s(i) * A_d$ 215 (FIG. 2) and the channel gain A_c (FIG. 2), and the received PCH signal, which is equivalent to the product of the transmitted PCH ($E_p(i) * A_p$) 221 (FIG. 2) and the

5   channel gain A_c (FIG. 2).   The process of separating the channels and symbols, and converting the symbols into energy is considered well known to one of ordinary skill in the art and, therefore, will not be discussed in further detail.

After separating the channels and symbols, and
10   converting the symbols to energy, processing continues to steps 312 and 314, which are preferably performed concurrently, wherein the average gain of the received FSHCH signal and average gain of the received PCH signal in a frame are determined. Upon completion of steps 312 and 314,
15   processing continues to step 316, wherein the gain ratio calculator 226 determines the quotient of the average gain of the received FSHCH signals for each frame divided by the average gain of the received PCH signals for each corresponding frame. The quotient, represented by $AVG(E_s(i)$
20   $* A_d * A_c) / AVG(E_p(i) * A_p * A_c)$, is approximately equivalent to the ratio of the gain of the FSHCH channel to the gain of the PCH channel, A_d/A_p.

The approximation can be derived by evaluating the received FSHCH signals and the received PCH signals. First,
25   assumptions are made that the FSHCH samples are distributed uniformly over the constellation over time, that the channel attenuation is the same for both the PCH and the FSHCH, and that the channel attenuation is independent of the FSHCH. Given these assumptions, the following average gain of the
30   FSHCH may be stated as:

$$\text{avg}(A_c * A_d * E_s(i)) = \text{avg}(A_c) * \text{avg}(A_d) * \text{avg}(E_s(i)) \qquad \text{(Eq. 1)}$$

Since it is assumed that the channel gain of the FSHCH channel is constant over a frame, Eq. 1 becomes:

$$\text{avg}(A_c * A_d * E_s(i)) = \text{avg}(A_c) * A_d * \text{avg}(E_s(i)) \qquad \text{(Eq. 2)}$$

Furthermore, since the $E_s(i)$ is assumed to be uniformly distributed over the constellation, the $\text{avg}(E_s(i))$ is approximately equal to 1, allowing the $\text{avg}(E_s(i))$ to be dropped from Eq. 2, leaving the following equation:

$$\text{avg}(A_c * A_d * E_s(i)) = \text{avg}(A_c) * A_d \qquad \text{(Eq. 3)}$$

Following similar logic for the PCH signal provides the following derivation:

$$\text{avg}(A_c * A_p * E_p(i)) = \text{avg}(A_c) * \text{avg}(A_p) * \text{avg}(E_p(i))$$
$$\text{avg}(A_c * A_p * E_p(i)) = \text{avg}(A_c) * A_p * \text{avg}(E_p(i))$$
$$\text{avg}(A_c * A_p * E_p(i)) = \text{avg}(A_c) * A_p \qquad \text{(Eq. 4)}$$

The ratio of the FSHCH to the PCH can therefore be expressed as:

$$\frac{\text{avg}(A_c * A_d * E_s(i))}{\text{avg}(A_c * A_p * E_p(i))} = \frac{\text{avg}(A_c) * A_d}{\text{avg}(A_c) * A_p} \qquad \text{(Eq. 5)}$$

Therefore, after eliminating the $\text{avg}(A_c)$ from the numerator and denominator, Eq. 5 becomes:

$$\frac{\text{avg}(A_c * A_d * E_s(i))}{\text{avg}(A_c * A_p * E_p(i))} = \frac{A_d}{A_p}$$

FIGURE 4 represents one embodiment for implementing the process described in FIGURE 3 in a hardware implementation, wherein accumulators and a divider are used to calculate the ratio of the gain of the FSHCH to the gain of the PCH. Preferably utilizing concurrent processing, an accumulator 410 receives as input the $E_s(i) * A_d * A_c$ and an accumulator 412 receives as input the $E_p(i) * A_p * A_c$. The accumulators 410 and 412 calculate the sum of the $E_s(i) * A_d * A_c$ and the sum of the $E_p(i) * A_p * A_c$, respectively, over each frame. The output of the of the accumulators 410 and 412 are input to a divider 414. The divider 414 determines the quotient of the $E_s(i) * A_d * A_c$ divided by the $E_p(i) * A_p * A_c$. Since a frame contains the same number of samples of the FSHCH and PCH per frame, a sum function may be used in place of the average function of Eq. 6 as follows:

$$\frac{\text{avg}(A_c * A_d * E_s(i))}{\text{avg}(A_c * A_p * E_p(i))} = \frac{\sum (A_c * A_d * E_s(i))}{\sum (A_c * A_p * E_p(i))} \qquad \text{(Eq. 7)}$$

The use of the SUM function is preferred over the average function because the sum function may be calculated more efficiently than the average function.

Alternatively, a sliding window method may be utilized. The sliding window method, well known in the art, is a method in which the division function, which is generally a time consuming function, is performed on partial data. A determination is then made upon the receipt of the additional samples whether the result of the division function would change significantly. If a determination is

made that the result would not change significantly, then the result based on partial data is used. If, however, a determination is made that the result would change significantly, then a second division is performed on the

5   complete and/or additional data.

It is understood that the present invention can take many forms and embodiments. Accordingly, several variations may be made in the foregoing without departing from the spirit or the scope of the invention. For example, the

10   present invention may be embodied in any device, such as a wireless/wireline telephone, computer, PDA, or the like, in a component configured to connect to a device, in a component configured as an element of a device, or the like.

Having thus described the present invention by

15   reference to certain of its preferred embodiments, it is noted that the embodiments disclosed are illustrative rather than limiting in nature and that a wide range of variations, modifications, changes, and substitutions are contemplated in the foregoing disclosure and, in some instances, some

20   features of the present invention may be employed without a corresponding use of the other features. Many such variations and modifications may be considered obvious and desirable by those skilled in the art based upon a review of the foregoing description of preferred embodiments.

25   Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the invention.